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4. Exclusive Use Equipment

4.1 AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM (AFIS)

4.1.1 Introduction

An individual's fingerprint is peculiar to its owner, and does not change throughout his life. Since E. R. Henry developed his fingerprint classification system, police agencies throughout the world collect, classify, and file the fingerprints of criminals in order to identify suspects.

Because it is possible to compare a partial fingerprint against fingerprints on file to identify an individual, it is possible to indicate suspects from latent prints left at the scenes of crime. Thus, fingerprints play an important role in criminal investigations.

However, this comparison process had to be done manually, requiring many specialists and much time.

Recent developments in computer use, image processing, and pattern recognition have changed this by making it possible to construct AFIS (Automatic Fingerprint Identification System).

In the mid-1960s, the U.S. Federal Bureau of Investigation (FBI) and the National Bureau of Standards (NBS) formed a team and began AFIS research. A few years later, the Investigation Division of the Japanese National Police Agency and the Central Research Laboratories of NEC began research to develop an AFIS system that could match latent prints.

In November of 1981, a pilot system was completed. The next October, the first operational system was installed at the National Police Agency. Matching was conducted from October 1983, after a year of database creation. This was the first system worldwide that could accurately match latent prints.

In 1984, the first NEC AFIS outside of Japan was installed at the San Francisco Police Department. Now, several NEC AFIS systems are installed in the United States, Canada, Europe, Australia, and the Middle East.

This paper discusses NEC fingerprint minutiae extraction and matching methods; core technologies of the NEC AFIS. Operational systems and future technological developments will also be discussed.

4.1.2 AFIS Fingerprint Minutiae

(1) Minutiae Representation

Figure 1 gives an explanation of fingerprint minutiae. Fingerprint images are made of lines called "ridges." Ridges contain end poitns and bifurcations called minutiae. Each fingertip contains about 100 minutiae. The minutiae positions of no two fingers are alike.

It is recognized that if 12 minutiae out of approximately 100 can be matched, then it is possible to determine that the fingerprints are from the same individual. This means that a partial fingerprint can be used to establish an individual's identity.

The FBI development group used the following method to represent minutiae:

$$M_i(X_i, Y_i, D_i). \tag{1}$$

where

i: Minutiae number.

X_i, Y_i: The X and Y values of the basic coordinates of the ith minutiae.

D_i: The angle between the X-axis and the ridges around the ith minutiae.

One problem with this method is the soft nature of

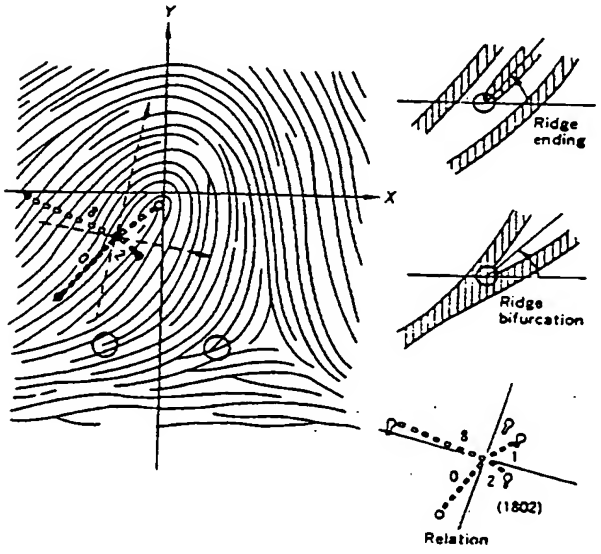


Fig. 1 Fingerprint and minutiae.

the skin. The fingerprint is easily distorted, changing the pattern in different ways depending on how the fingertip is pressed when the print is left. This pattern distortion is severe in latent prints left at crime scenes.

To overcome this problem, NEC incorporated the ridge count between minutiae in their representation of minutiae because this data is unaffected by fingerprint distortion. Minutiae are represented as:

$$M_i(X_i, Y_i, D_i, r_{i1}, r_{i2}, r_{i3}, r_{i4}). \quad (2)$$

Here, r_{i1}, r_{i2}, r_{i3} and r_{i4} are determined in the following way. An origin point defined by (X_i, Y_i), and the ridge flow direction defined by D_i becomes the Y-axis through the origin point for local coordinates. An X-axis for local coordinates is then placed perpendicular to the local Y-axis through the origin point.

The area around M_i (parent minutiae) is divided into four quadrants for local coordinates. The value of r_{i1} is the ridge count between M_i and the nearest minutiae (child minutiae) in quadrant i1. This process is repeated for the remaining three quadrants. NEC calls this ridge count between the parent minutiae and the child minutiae "relation."

(2) Fingerprint Minutiae Extraction Method

A simplified processing flow is shown in Fig. 2. When a fingerprint image is scanned, a Charge Coupled Device (CCD) converts it into a digital image (Photo 1(a)) with a resolution of 50 μm × 50 μm/pixel with 8 bits/pixel. After preprocessing, which includes enhancement and smoothing, this is converted to 4 bits/pixel. Ridge direction is then determined for each 31 × 31 pixel local area.

Using the ridge direction, a binary image is extracted and goes through a ridge thinning processing, then the value for $M_i(X_i, Y_i, D_i, r_{i1}, r_{i2}, r_{i3}, r_{i4})$ is determined. A visual display of the thinned ridges and extracted minutiae is shown in Photo 1(b).

Our high-speed reader uses a specialized pipeline processor to conduct the image processing described above, and can extract minutiae data at the rate of 1.5 seconds per finger.

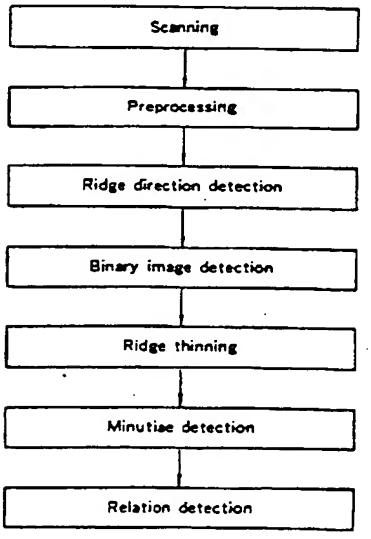


Fig. 2 Image processing and minutiae detection flow.

4.1.3 Matching Method

This matching scheme is applied to latent prints as

Photo 1(a) Digitized fingerprint image.

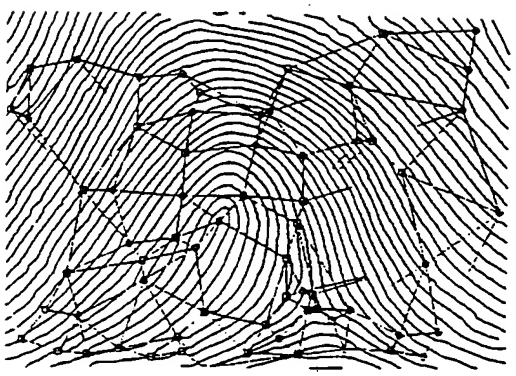


Photo 1(b) Thinned ridges, and extracted minutiae.

well as tenprints. Due to space constraints, only an outline of this matching scheme will be described.

When a search print F^s is compared with a file print F^f in the database, all minutiae from

$$F^s\{M_i^s(X_i^s, Y_i^s, D_i^s, r_{i1}^s, r_{i2}^s, r_{i3}^s, r_{i4}^s),\ i = 1, 2, 3, \cdots\} \quad (3)$$

and

$$F^f\{M_j^f(X_j^f, Y_j^f, D_j^f, r_{j1}^f, r_{j2}^f, r_{j3}^f, r_{j4}^f),\ j = 1, 2, 3, \cdots\} \quad (4)$$

are located by the matching processor.

All possible combinations of pairs are checked to locate assumed mates.

Minutiae close to the core of F^s are compared with a relatively small tolerance to the minutiae close to the core of F^f, and minutiae farther from the core are compared with a relatively greater tolerance to compensate for gradually increasing distortion.

The X-Y coordinates for parent minutiae M_i^s, M_j^f and their neighboring minutiae are adjusted so that both local coordinates that are used to determine the relationship correspondingly overlay.

Then the corresponding relation (ridge count) is checked for the child and grandchild minutiae of M_j^f which meet the position and direction allowance against child minutiae of M_i^s.

A similarity value for each candidate minutiae mate is calculated, all parent minutiae candidate mates are listed, and the total score for the fingerprint is calculated using the similarity values.

This matching score is calculated for all F^f of the operator determined portion of the database, and a candidate list is output in descending order of score.

The matching processor is a dedicated parallel processor that can match around 1,000 fingerprint pairs per second.

4.1.4 Operational System

An operational system configuration is shown in Fig. 3. The system is divided into three subsystems.

- Input subsystem — I-Sub
- Matching subsystem — M-Sub
- Digital image retrieval subsystem — D-Sub

The fingerprint card is input at the I-Sub. Then minutiae are extracted as described in Section 4.1.2 above. After minutiae extraction, the minutiae data is stored in the M-Sub, and the compressed image data is stored in the D-Sub.

The M-Sub database is typically divided into three databases.

- Rolled-print Database for Tenprint Inquiry (RDB-T)
- Rolled-print Database for Latent Inquiry (RDB-L)
- Unsolved Latent Database (LDB)

The RDB-T normally contains the minutiae data for the right and left thumbs, and is partitioned into bins according to a pattern classification that accounts for pattern type and corresponding finger number for all ten fingers of a tenprint card. This database is used to compare the minutiae data from the right and left

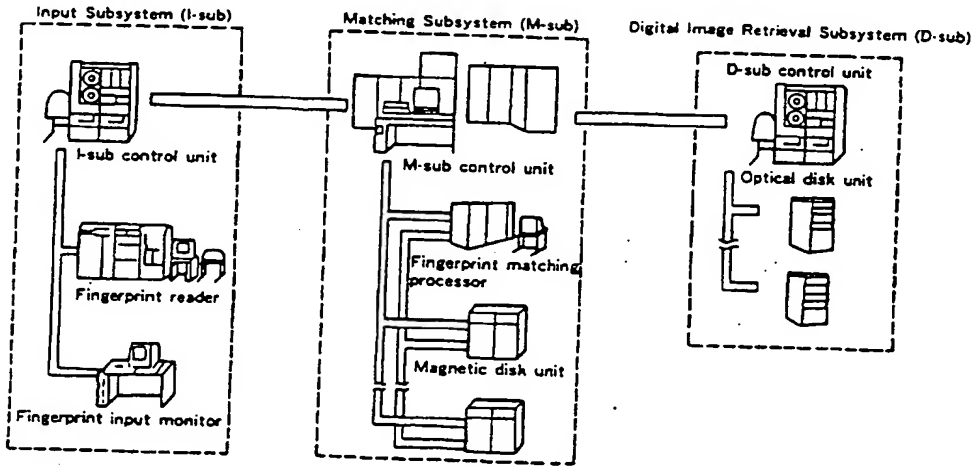


Fig. 3 AFIS system configuration.

thumbs of a search tenprint card.

The RDB-L contains the minutiae data for all ten fingers from a tenprint card, and is divided into bins according to finger number and pattern type. This database is used to compare the minutiae data of latent prints.

The LDB contains the latent prints from unsolved crimes, and has been divided into bins according to finger number and pattern type. Bins labeled "unknown" have been prepared for latent prints when this information is unknown.

The D-Sub contains the optical disk unit where the digital images corresponding to the minutiae data stored in the RDB-T, RDB-L, and LDB are stored. Link addresses for all images are stored in the M-Sub, and the binary or gray images are compressed using the Predictive Code and Image Analysis Adaptive Discrete Cosine Transformation method before they are stored in the D-Sub. Images are compressed to between approx. 4K bytes (binary) and 10K bytes (gray).

When a search print (tenprint or latent print) is compared against database, it is input at the I-Sub and the minutiae are extracted as explained above. If known, descriptive information, such as pattern type or finger number, is entered by keyboard and then sent to the M-Sub for matching against the database.

After matching, candidates are assembled in descending order according to their scores and output to a terminal or printer. When an operator verifies whether the candidate is a hit or not, the corresponding search and file images in the D-Sub are retrieved and displayed at a verification terminal in split-screen mode. This allows the operator to view both prints simultaneously and verify whether or not a hit has occurred. Photo 2 shows officers using an operational AFIS.

Photo 2 Officers using an operational AFIS.

4.1.5 AFIS Networks and Remote Sites

NEC's remote terminals have the capability to read search prints, extract minutiae/relation data, and then send this data to a regional AFIS for matching. When matching occurs, the central AFIS sends the candidate list and images to the remote terminal for verification.

When matching does not occur, the remote terminals are capable of sending an inquiry to the central AFIS through the regional AFIS and retrieving the candidate lists/images from the central AFIS.

4.1.6 Conclusion

NEC has succeeded in developing the world's most accurate and effective automated fingerprint identification system. NEC can provide both large- and small-scale systems.

The flexibility of the NEC AFIS also allows it to be interfaced with many peripherals developed by NEC, enhancing the system and further aiding the process of criminal identification. Many peripherals are available, such as a mug shot system for storing criminal photos on optical disks, an economical booking terminal with a scanning device for processing fingerprints at remote sites with small workloads, and a live terminal that reads fingerprint data directly from the finger and compares it with the database.

These many functions can be of great use, not only in criminal identification, but in many other applications as well. We hope to use the skills developed in these technologies in a wide variety of fields. This technology could lead to instant fingerprint identification for entrance into high security areas, customs and immigration control, or even airport security checks.

(Kazuo KIJI, Yukio HOSHINO and Koh ASAI)

4.2 NON-VON NEUMANN COMPUTER "NEDIPS"

4.2.1 Introduction

The need for high-speed computers with massive data processing capability are never-ending. In order to attain a drastic increase in computer power, an entirely different approach, a study of the so-called non-von Neumann architecture, has been carried out. Among them is a quite attractive one, a data-flow computer. Data-flow computers extract concurrency of computation involved in a program and enable a flexible and efficient use of multiprocessors.

NEDIPS is the world's first practical non-von Neumann-type, high-speed computer system which adopts a data-flow architecture. Efficiency of the hardware in the field of image processing has been proved in practical use such as in data processing for

Synthetic Aperture Radar (SAR) and so on.

4.2.2 Hardware and Software

NEDIPS is used as an attached processor under the control of a host computer which is an ordinary von Neumann type computer such as the MS series and the ACOS series. Photo 3 shows the overview of NEDIPS.

As shown in Fig. 4, NEDIPS consists of a Data-Flow Processor (DFP) and a Memory Unit (MU). DFP consists of a Control Unit (CU) and ring units. CU consists of a microcomputer system and controls MU and DFP by receiving commands from the host computer.

In the ring unit, operation modules are connected in a ring. There are several kinds of modules for various kinds of operations. In each module, a program called template is stored in its program table. The template is different from a conventional program in the following respect: A conventional program specifies the sequence in which processing is carried out. The template, however, does not specify the processing sequence, but rather how data are processed in the module and to which module the data are sent. Some kinds of modules have a submodule called QCM (Queue Control Module) for dyadic operation. If data is incomplete for the dyadic operation, it is temporarily stored in the queue memory and processing starts whenever other data to be paired has arrived.

There are three standard models of NEDIPS, models 10, 20, and 30, defined by number of ring units. If

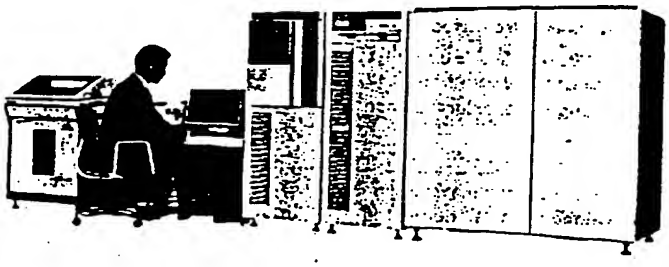


Photo 3 Overview of NEDIPS.

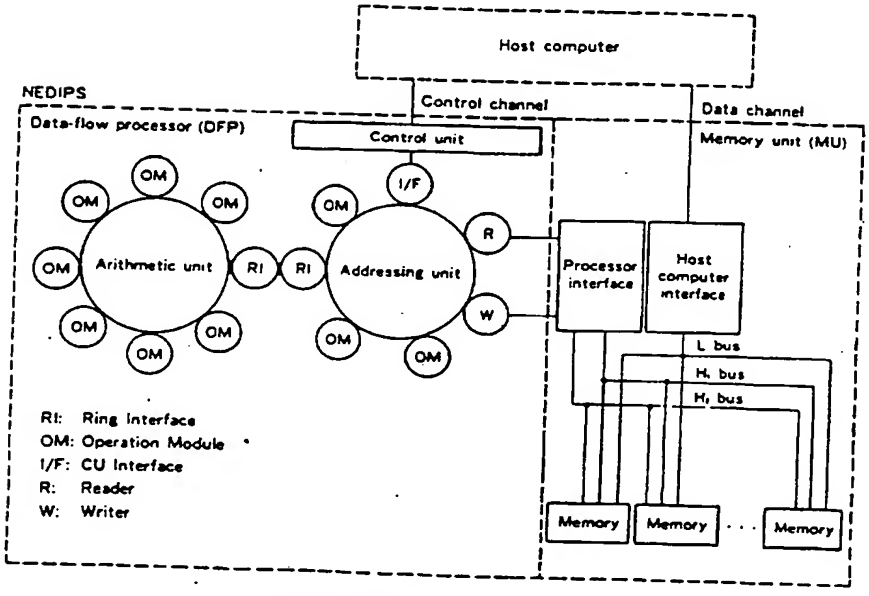


Fig. 4 NEDIPS system block diagram.

needed, one can add an extra ring unit, which has operation modules for special use, such as FFT or double precision operation or image memory.

In order to use NEDIPS, several software packages are available. To control NEDIPS form host computer, a program package, the template executive, is used. To make programs of NEDIPS, a template assembler language and a macrolibrary are used.

4.2.3 Applications

The first application of NEDIPS is high-speed SAR data processing. SAR is a high-resolution, microwave, active imaging sensor with all-weather. A very large number of operations are required in SAR data processing, and one hundred hours of computing time was required for a general-purpose computer system. By using NEDIPS, it can get done within about four hours. And it can be completed in less than one hour, using an extra module. NEDIPS is also used in a newspaper photo-translating system to get high-quality photographs. NEDIPS can emphasize the edge of the photograph, reduce noise, and change the color balance in a few minutes.

4.2.4 Conclusion

NEDIPS was originally developed as a dedicated processor for high-speed calculation of FFT and complex vectors. Later its programmability was enhanced to expand its applications to calculation of general scientific and technical data. At present, various applications continue to be developed and evaluated.

(Hitoshi NOHMI)

4.3 ELECTRONIC FILING SYSTEMS

4.3.1 Products Line

Electronic filing systems using optical disks are attracting attention as new information management systems by which users can store large numbers of documents and drawings in small storage space and easily retrieve and edit them on their workstations.

Since users who want to install an electronic filing system tend to a demand links with the basic data-base of a host computer and multiretrieval over an LAN (Local Area Network), we view electronic filing systems as a general-purpose facility for computer processing. In 1983, NEC commercialized an electronic filing system which can be used on an N6300 Model 55 intelligent terminal. And in 1987, NEC introduced its successor for large-scale multiple users which can be used on an S3050 office processor (small business computer) and the stand-alone workstation N5300AD. The S3050 is shown in Photo 4.

Many users want to install an electronic filing system as a stand-alone system in a specific department. To meet their needs, NEC introduced the specialized electronic filing system NEOfile 1000 in 1984, and then its successor NEOfile 300 series with expanded network features in 1988.

Thus, NEC currently offers electonic filing systems in the form of the general-purpose system S3050/N5300AD and the dedicated systems in the NEOfile 300 series.

Recently, NEC also developed the VP-500 and the Pictionary, both of which are full-color image file systems, to the design market where animated and still images form a key information resource.

4.3.2 Electronic Filing System Technology

Electronic filing systems provide the following four main functions:

- Enrolling: Files documents and drawings easily and quickly.
- Retrieval: Retrieves necessary information quickly.
- Editing: Processes information into an easy-to-use form as needed.
- Printing: Copies documents instantly in an easy-to-see form.

Table I shows the components of electronic filing systems providing the above functions.

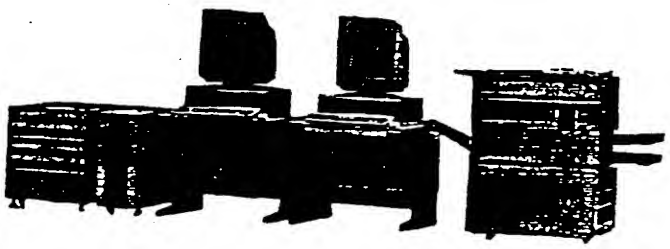


Photo 4 NEC System 3050.

(1) Image Scanner

An image scanner allows input of documents and drawings. Three kinds of image scanners are available depending on document size (Table II).

(2) Encoding

Since the amount of the image data read through an image scanner is very large, for example, 16 MB for an A1 size document, data is compressed to 1/10 to 1/20 of original size before it is stored. This process is called encoding. Three encoding methods are available:

- MH (Modified Huffman) encoding method.
- MR (Modified Read) encoding method.
- MMR (Modified MR) encoding method.

(3) Filing Unit

The electronic filing system uses an optical disk unit as its filing unit to store large amounts of information. The user can select a suitable type of unit from among our offerings (Table III).

(4) Retrieval Function

Four kinds of efficient retrieval functions can be used depending on what you want to do, permitting anyone to obtain necessary information easily and quickly (Table IV).

(5) Display Unit

A 17 inch, high-resolution CRT is used so that a full-letter-size 200 dpi document can be displayed clearly

Table I Components of the electronic filing system.

Function	Component	Description
Enrolling	Image scanner	Converts documents and drawings into image data
	Encoding	Compresses image data
	File unit	Mass storage file unit
Retrieval	Retrieval function	Retrieves necessary information quickly
	Display unit	Displays image data
Editing	Editing function	Processes image data
Printing	Image printer	Prints image data

Table II Image scanners.

Item \ Type	B4 scanner	A3 scanner	A1 scanner
Input time	8 sec/A4	2 sec/A4	34 sec/A1
Resolution (dpi)	200/400	200/400	200/400
Gray levels	16/64	16/64	—
Automatic document feeding	—	Available	—

Table III Optical disk units.

Item \ Type	2G	3.6G	0.6G	Jukebox type
Media size (inch)	12	12	5	12
Capacity (GB/double-sided)	2	3.6	0.6	2
Number of disks	—	—	—	48
Access time (ms)	270	650	93	270
Media life (years) (minimum)	10	10	10	10

Table IV Retrieval functions.

Method	Description
Menu retrieval	Retrieves a document filed hierarchically by selecting a number in the menu.
Cross retrieval	Retrieves documents from separate files.
Table retrieval	Retrieves a document listed in a table by using the following efficient methods. – Direct retrieval – Keyword retrieval – Logical retrieval
View retrieval	This is NEC's original retrieval method, allowing documents to be easily retrieved by selecting pictures using a mouse.

Table V Image printers.

Item \ Type	B4 printer	A3 printer	A1 printer
Output size (Max.)	B4	A3	A1
Resolution (dpi)	400	400	400
Paper type	Plain	Plain	Plain

down to the details, such as fine lines and small numbers.

(6) Image Editing Function

The electronic filing system provides a variety of useful editing functions, such as overlay, delete, character composition, move, crop, enlarge, and reduce.

(7) Image Printer

The following three types of 400 dpi resolution image electrophotographic printers are available to print not only general documents and magazines but also drawings and designs which require high precision (Table V).

4.3.3 Conclusion

The use of the electronic filing system as a document processing system grows in parallel with cost reduction which will be brought about by improvements in optical disk technology, such as development of 3.5 inch and rewritable disks. The electronic filing system will also become linked more closely with computer systems as ISDN (Integrated Services Digital Network) and LANs propagate.

NEC will continue to enhance its electronic filing systems to meet the needs for integration with general-purpose systems by enhancing their ease-of-use, offering more advanced peripherals, and providing additional document processing features.

(Koichi SHOYA)

4.4 POS TERMINALS AND PORTABLE TERMINALS

4.4.1 POS Terminals

(1) Market Trend

In order to cope with the needs of diversified and personalized consumers, companies in the distribution industry must now be reformed so that they may be managed more efficiently focusing on profitability.

A trend to Store Automation (SA) is highlighted within such a background, and many store in the distribution industry are adopting information processing systems as a means to survive. The Point of Sales (POS) system is one of these and used to manage information at each point of sales so as to improve the rationality of store management.

A POS system can provide the store manager with information concerning left-on-the-shelf goods and stock on the spot by collecting information concerning goods using POS terminals installed in the store. It is expected that installation of those POS systems in stores as a useful system for rationality and efficiency of management will be all the more needed in the future. Competition among POS system makers is thus getting more and more severe.

The distribution industry POS terminal market has a very wide range: department stores, supermarkets, restaurants, and specialty stores are included in the market.

NEC, having management know-how of specialty stores such as home electric appliances stores, restaurants, and sporting goods stores, is occupying the top share in such the market and provides customers with application software packages for each specialty type store.

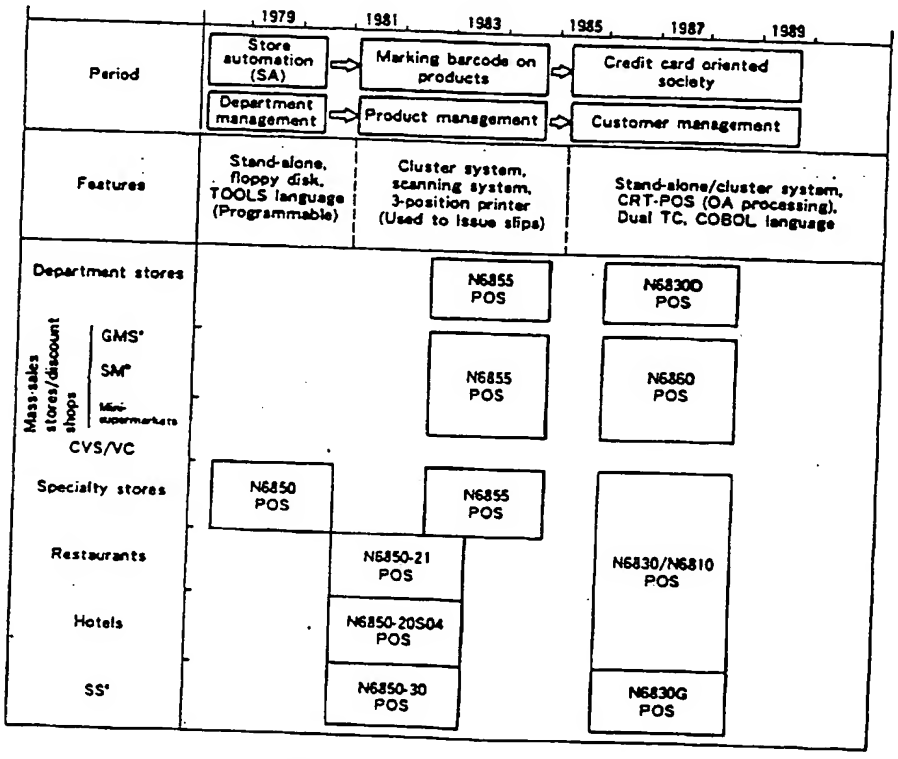
(2) History of Products

NEC put the first intelligent POS system (N6850) into the market in 1979. A microprocessor is used for the POS system. Since then, the system has been developed into several series, supplying the C&C POS systems to the distribution industry market.

The NEC POS series as shown in Fig. 5 and Photo 5 has been manufactured in "three generations" as shown below, always with new technology matching the needs of the market at that time. The first-generation started in 1979, the second-generation in 1983, and the third-generation in 1986.

1) The First-Generation
N6850 POS system was programmable intelligent POS systems. A microprocessor (Z80) was mounted on each of the POS terminals. It was developed for specialty stores. This N6850 POS system was a stand-alone type for which 5 inch floppy disk drives were used. Using a simple language TOOL-S, its functions could be flexibly modified by users. The market for the POS system could also be widened to include restaurants, hotels, and service stations.

2) The Second-Generation
N6855 POS system expanded the functions of the N6850 POS system, targeting mass-sales stores/discount shops. In 1982, when JAN (Japanese Article Number) codes had just been standardized, JAN-POS systems were urgently needed.
To meet market demand, NEC developed a cluster-style POS system (N6855 POS system). Connected



*GMS: General Merchandising Stores
*SM: Supermarkets
*SS: Service Stations

Fig. 5 History of POS products.

to multiple POS terminals under the control of a TC (Terminal Controller), it loads programs from the TC. In this N6855, a newly developed "barcode scanner" was adopted for the operator to read JAN-code faster in mass-sales stores/discount shops. This system is the basis of the current scanning POS system.

In addition, another model used for department stores was also developed from the N6855. In this system, a 3-position printer is mounted. The printer prints out receipts/journals/slips concurrently. The POS system attracted considerable attention as a new-type POS system.

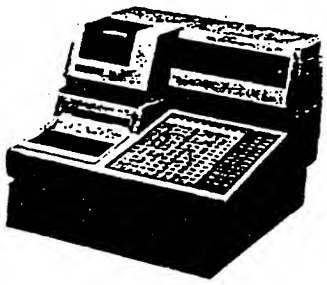
) The Third-Generation

The third-generation POS system was a POS system developed on the basis of the first- and second-generation POS systems. It creates application software using COBOL. The third-generation POS system was divided into two models: cluster type N6860 and stand-alone type N6830.

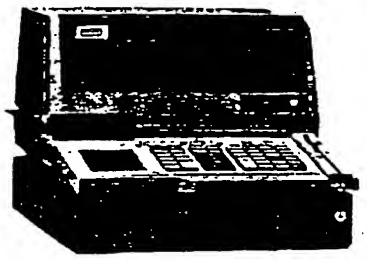
In the N6860 POS system, developed on the basis of second-generation N6855 technology, realization of trouble-free system in dual TC system, as well as harmony with host system were emphasized. And each POS terminal was modularized so that it might be specialized as a compact scanning POS system for mass-sales stores/discount shops.

In contrast, the N6830 POS system was developed in recognition of the onset of the store automation age. A 9-inch CRT is mounted on the system, which creates application software for diverse jobs determined by the user. In this system, compatibility with the N5200 series, harmony between stores, and OA are emphasized. Thus, it is also referred to as an OA-POS system.

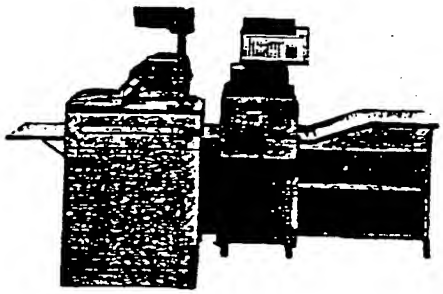
At that time, OA-POS-type systems were not manufactured by any makers. When the N6830 (OA-POS) was introduced in the market, therefore, it seemed to come as a great shock to other POS makers. Now that POS systems with CRT can be seen everywhere, NEC feels that the N6830 was really a pioneer in the field of CRT-POS systems. The N6830 is especially evaluated its intelligency which can solve problems that could not be solved by ECR, as well as it was designed to be compact



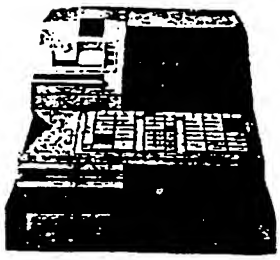
(a) N6850



(b) N6855



(c) N6860



(d) N6830

Photo 5 NEC POS products (1st- to 3rd-generation).

in size in view of smaller store spaces.
Along with the lineup of various I/O peripheral devices, software packages of business know-how have been enriched, and a large number of those software packages have brought C&C NEC POS systems to their currently immovable position as leaders in the current POS market.

(3) Next Theme

Competition in the POS market in the distribution industry will become more severe in the future. In such circumstances, NEC will do its best to remain the leader and to expand the market. The following is a description of NEC's thinking in this area. A POS system is a cash register in any case. So, as a mainframe maker, NEC cannot make way to those register makers and must keep seeking ways to make POS systems more controllable. It will also be needed for us to change the conception of POS system sales – from hardware-oriented sales to software-oriented (service-oriented) sales, as well as from SA-POS (Store Automation) sales for efficient and profitable management of stores to SA-POS (Service Approach) sales with high performance for attracting more customers.

In order to meet the above needs, NEC will keep the top market share and expand the POS market by introducing ideal POS systems that are useful for stores (store chieves), customers, and user systems.

(Hiroshi MATSUMOTO)

4.4.2 Portable Terminals

(1) Introduction

Portable terminals are rapidly increasing in sales, since they can be used for outdoor sales activities that have been difficult to pursue efficiently so far.

Portable terminals are used in almost all outdoor office in retailers, wholesalers, drugs wholesalers, daily necessaries wholesalers, soft drink wholesalers, transporters, governmental offices, banking office, etc. Data entered on the spot can be processed in the host system in the office only by connecting the terminal to the host system.

NEC joined in development of this portable terminal in its early stages and has kept occupying the leading position in the domestic market.

This section will introduce the development activities of NEC's portable terminals during the past ten years.

(2) Outline of Portable Terminal

A portable terminal, as shown in Fig. 6, consists of a keyboard, a display unit, memory, a CPU used to control these, and a battery (power supply). All these components are organized in as compact a manner as possible so that it can be carried in one hand.

You can bring such a portable terminal anywhere, enter data in the terminal directly on the site where it is generated, and send the data to the host computer via a telephone line by using an acoustic coupler on the very site. The data can also be entered to the host computer by connecting the terminal to it directly. When a printer is connected to the terminal, the data can be summed up and printed out as slips. Using a portable terminal can improve the efficiency of summing up and processing collected data.

(3) History of Portable Terminal Development

Both N6916H and N6917H were developed between 1979 and 1980 as terminals used for retailers to order supplies at the shelf of target goods. They are each controlled by an EOS (Electronic Order entry System) terminal.

In those days, there were very few CMOS devices (CPU, RAM, UART, etc.) operatable by battery. RAM capacity was also around 8K bytes to 32K bytes.

N6919-40 was the first portable terminal for which COBOL was adopted as a language, though languages such as Assembler had been used for portable terminals in those days. And with this, the efficiency of application program development was remarkably improved.

It enabled connections to a business personal computer, intelligent terminal, and office processor to be made. As a result, the application range of the portable terminal was widely expanded.

N6919-40H was a portable terminal in which the number of digits to display, as well as the memory capacity were expanded. A 128K byte memory card also was mounted in the terminal so that the terminal could construct larger programs and handle mass data. For this terminal large-size hybrid ICs had been developed and were adopted for realizing a compact and lightweight terminal.

N6919-60H, increasing the number of digits displayed and adopting a touch panel, not only enabled its menu screen to be set and data to be entered more easily, but its memory capacity could also be expanded to 1M bytes (Max.). In this portable terminal, a dedicated 16-bit microprocessor was adopted in order to realize compact and high-performance terminal. The microprocessor was developed specifically for this terminal. With this microprocessor, the four LSIs that had thus far made up the terminal circuits could be integrated into only one LSI.

The history of NEC portable terminals is shown in Fig. 7.

(4) Future Developments

Portable terminals mentioned above will be made all

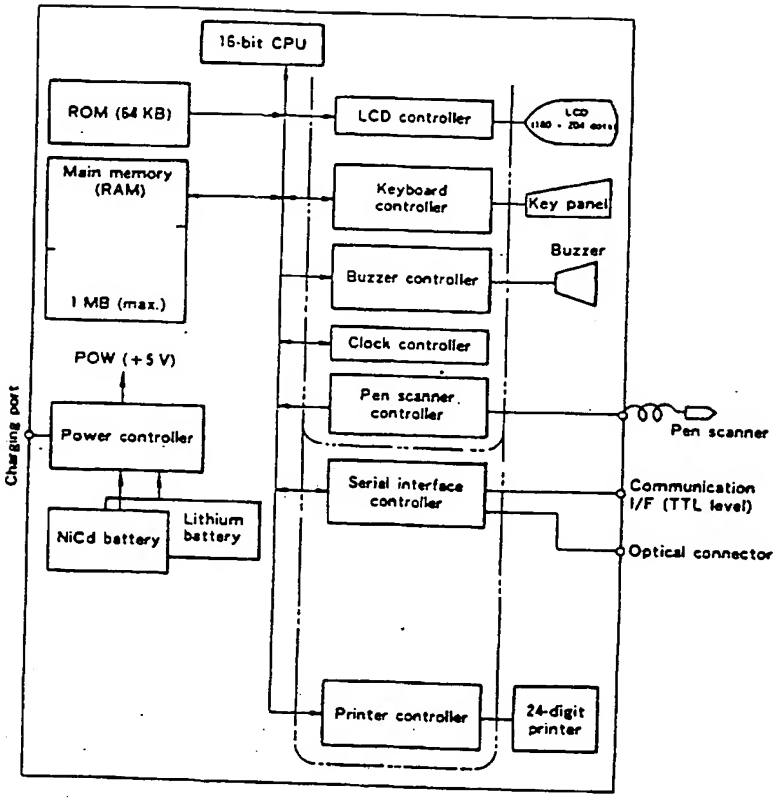


Fig. 6 Hardware block diagram of portable terminals.

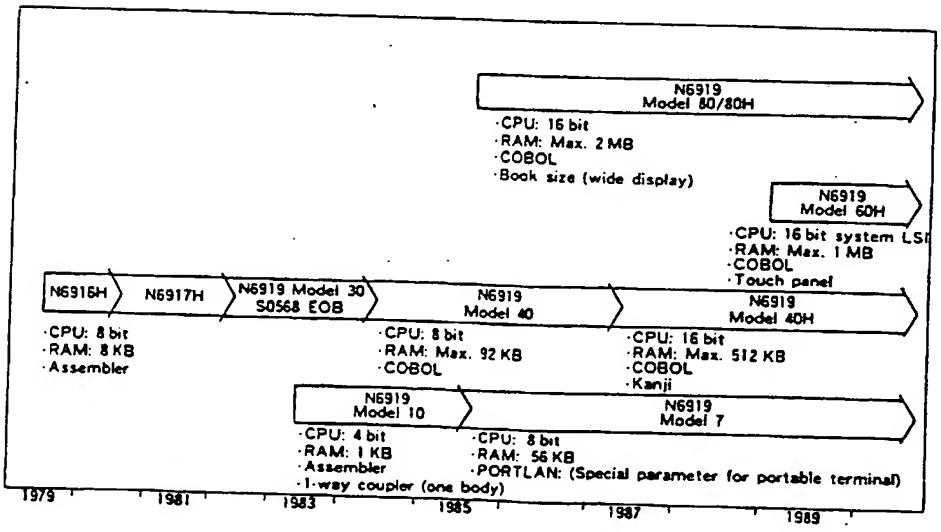


Fig. 7 History of NEC portable terminals.

the more compact and lightweight by integrating electronic circuits into a CMOS LSI on the basis of NEC's electronic device technology. And not only conventional modems, RS-232C interfaces with host systems, but also optical communication modules, wireless modules, etc., to be developed will be used as communication means. (*Satoru NARITA*)

4.5 BANKING TERMINALS

4.5.1 Banking Terminals as Teller Machines

NEC first manufactured banking terminals for financial organizations as the N6190 series in 1974. Since then, electrobanking systems used in banks have been rapidly developed and increasingly used. Such banking terminals are required to function efficiently and deliver high performance. NEC began producing banking terminals in 1988 in real earnest, and the 6th generation, the N8310 general-purpose terminal for sales stores is now being produced. It is the core system of N8300 financial information systems.

Figure 8 shows the history of model changes with respect to financial banking terminals produced by NEC. N6190 I in 1974, N6190 II in 1976, and N6190 III in 1978 are cluster-type systems, each consisting of a terminal controller and a banking terminal. A banking terminal consists of a display, a keyboard, and a printer (for passbooks/slips). All those components are united into one. The N6190 II can perform horizontal ejection of passbooks/slips automatically. It incorporates a cassette magnetic tape unit within it as a file unit.

In the N6190 III, the printing speed (40 characters/sec in N6190 II) was improved three times (120 characters/sec), and it can handle limited Kanji characters as well. As a file unit, either cassette magnetic tape unit or floppy disk unit can be selected. The N6190 IV introduced in 1981 was a machine exclusively used for on-line banking processing. It enabled a connection to be made to teller processing for the first time. The terminal was a compact all-in-one type, which could be installed on a desk and connected to a line.

The N6195 K-OTM (On-line Teller Machine) introduced in 1983 was a genuine teller terminal corresponding to data processing in Japanese. It had the standard JIS 1st level Kanji character set as the standard and its passbook printer, display, keyboard, and controller were all modularized. Each unit was compact in size and laid out freely according to the operation at the window in the bank. The passbook printer had an insertion slit and an eject slit that were arranged horizontally. It could print out data in 24 × 24 dots (high quality).

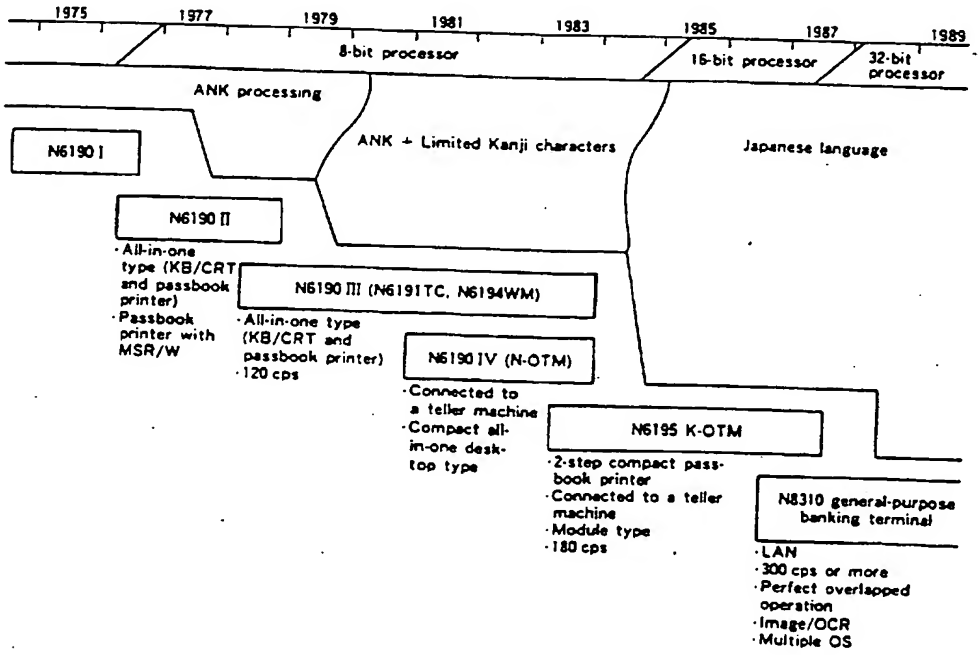


Fig. 8 History of NEC banking terminals.

Indentification of tellers by their keys and ID cards, as well as security of customer input information by password were also considered as part of the system security.

The N8310 general-purpose banking terminals (see Photo 6) that were produced in real earnest in April 1988 had the following features. The terminal was produced through a joint effort: NEC provided advanced technologies and the Sumitomo Bank, Ltd. provided the know-how concerning the banking field.

1) The terminal for which a 32-bit processor is adopted first corresponds to high counters/low counters, back offices, and supervisor desks flexibly using the same controller in accordance with the one-machine concept of the terminal.
2) Horizontal distributed processings are possible when connected to a local area network (branch type).
3) The passbook printer can print out data at 300 cps (ANK) or more, as well as perform overlapped operation (next data key-in possible during printing) due to separation of insertion port from eject port. It can also incorporate a contact-type image scanner. When the image scanner is linked to the incorporated OCR, the terminal can recognize printed alphanumeric character.
4) Multiple operating systems are supported. Thus, banking jobs and information processing jobs can be handled under different operating systems appropriately selected.

Future banking terminal processing will be divided into routine jobs and more sophisticated consulting jobs. The routine jobs such as teller processing will be shifted to automatic devices. And more advanced functions and higher performance will be all the more required for such banking terminals.

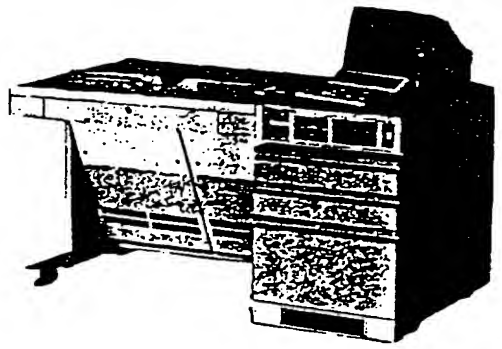


Photo 6 N8310 general-purpose banking terminal.

To meet these needs, NEC will promote research and development in the areas of AI, LSI, and "mechatronics" technologies. *(Noriyuki SENUMA)*

4.5.2 Automatic Teller Machines/Cash Dispensers (ATM/CD)

NEC started development of ATM/CD in 1979, when the N6891B cash dispenser was completed. Since then, new machine models have been put in the market while company-developed technologies are being accumulated. Figure 9 shows the NEC model changes of ATM/CD. In 1979, N6891B-CD was completed, and in 1981, N6893-ATM, N6891C-CD, and N6891E-CD were completed. And in 1986, N6894-ATM and N6891D-CD were completed, while N8353/54-ATM was completed in 1987. Products have been improved/reinforced in cycles of two to four years. Photo 7 shows N8354 Recycle-ATM.

From the technical point of view, the first N6893-ATM had both a stocked in unit and paying-out unit of bank notes that operated independently of each other. However, in the N6894-N8354 ATM, both units were united into one. Received bank notes could be recycled as paid-out bank notes. Thus, efficiency in circulating bank notes could be greatly improved.

Since its size was also greatly reduced, the conventional coin deposit/withdrawal unit could be mounted in the same space as that of the conventional ATM so that the machine could also correspond to money transfer operations, as well as payment of interests for bonds, securities, etc., in addition to deposit/withdrawal operations. Thus, the space taken up by the machine could be greatly reduced. The cost performance of the following items was also improved compared with that of the N6893-ATM.

- Mounting display of Kanji characters and printing functions.
- Mounting IC card functions.
- Improvement of customer guidance/operatability, as well as an increase in number of jobs performed due to reinforced functions shifted from 9 inch color CRT/KB to 12 inch color CRT/touch panel.

Technical features to be adopted for the next generation ATM will include the following:

Image recognition technology for genuine/counterfeit bank note judgment, high-speed counting at 10 bank notes/sec, carrying/depositing/separating/dispensing of bank notes from cash cassette, as well as "mechatronics" technologies for automatic turning of pages of passbooks, and high-density packing technologies for mounting those functions in a compact space.

In addition, the following is also expected to be achieved: Improvement of unmanned functions for

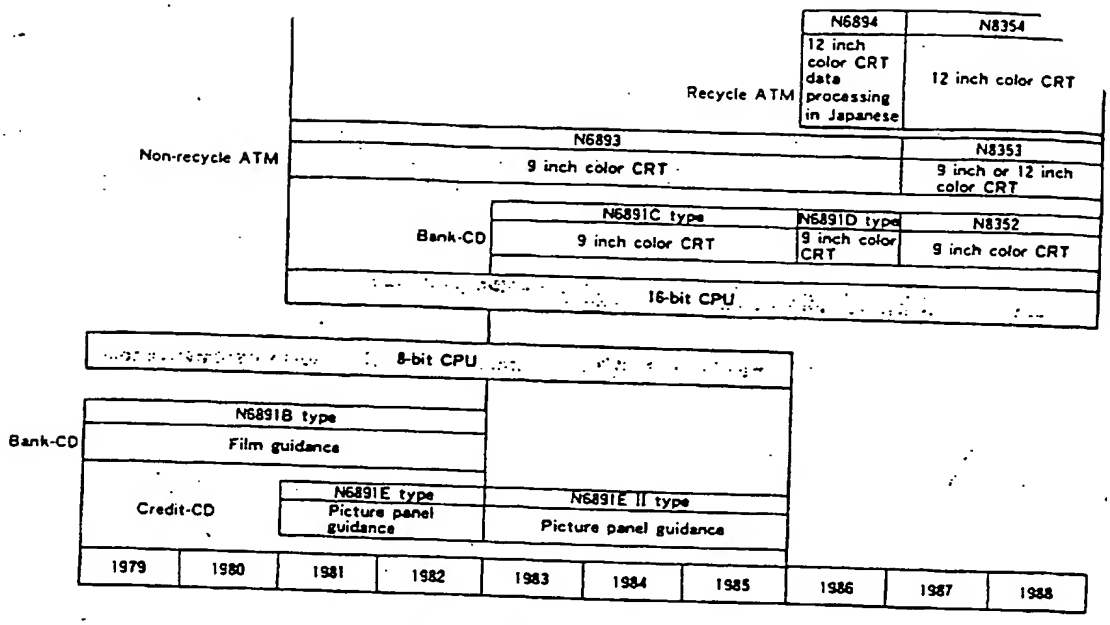


Fig. 9 Model changes of NEC ATM/CD.

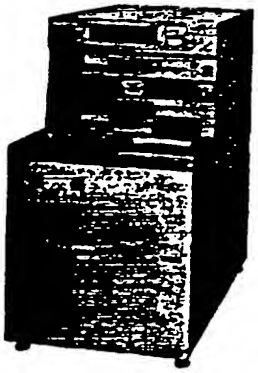


Photo 7 N8354 Recycle-ATM.

overtime operations (24-hour operation) and holidays, reliability of ATM itself for efficient unmanned operations, installation space saving for expansion of ATM to cover sudden rises of land prices, and high performance for number of transactions/ATM.

To meet those needs, NEC are promoting research/development for AI technology, multimedia processing technology (technologies to shrink/expand images, as well as to transfer data via network), "mechatronic" technology (improvement of usage of electronics), LSI technology, image recognition technology (high-speed processing), etc.

(Masanori ISHII)

4.5.3 Agricultural Terminals

Teller terminals for small/medium-scale financial organizations, such as agricultural/fishermen's co-operative associations were first manufactured in 1975 as the N6390 series. Since then, the terminals have been improved/reinforced in cycles of two to four years.

Figure 10 shows the history of N6390 model changes. In each stage of the model changes, products were released on the market so as to meet the needs of customers. The agricultural market share of NEC is now a little above 40%.

Technical progress of N6390: At first, the N6390 type I was a stand-alone type. Its controller, passbook printer, CRT display, and file unit were all united into one. The terminal was used for on-line banking processing. In the N6390AG, each such unit is compacted and modularized so that it can also be used for

information processing; in addition, the system configuration and layout can be selected appropriately for the target processing and the setting of conditions (Photo 8).

The N6390AG configuration can be appropriately selected for a stand-alone system to cluster system with respect to the cost-performance and processing amount. Compared with the N6390 type I, the cost-performance of the following items was improved in the N6390AG.

1) Mounting functions of data display in Japanese and functions of printing data in Japanese.
2) Mounting COBOL language functions.
   By using COBOL that is excellent in general-purpose properties and productivity, the user can easily create application programs.
3) Supporting package software such as OA software, various communication emulators, etc.
4) Supporting a variety of I/O devices.

One unit of this terminal has come to be able to correspond to a variety of processing including banking jobs, information processing jobs and management jobs, as well as OA processing.

The features of the technology adopted for N6390AG are as follows.

(1) Adopting Multiprocessor (32-bit MPU/16-bit LPU)

A multiprocessor architecture is adopted. The architecture includes a processor (LPU) exclusively used for controlling I/O devices such as passbook printer, cash processing unit, etc., as well as an application processor (MPU) used to execute various job processings.

(2) Mounting Network and MML (Micro MainFrame Link) Functions

Flexible correspondence to high-level communication networks including the DINA (Distributed Network

		1975	1979	1983	1986	1989
Ages		Intelligent	Multi-workstation	Correspondence to Japanese language		OA/image processings
Product flow		N6390 type I N6390 type II	N6390 type III N6390 type IIIA	N6390 type V	N6390 type Vs/Vx	N6390AG
Features		① Passbook printer vertical insertion/ejection ② All-in-one type (KB/CRT and passbook printer) ③ Subject: Banking processings ④ ANK processings	① Improvement of controllability due to passbook printer horizontal insertion/ejection ② ANK + Limited Kanji characters	① Horizontal 2-step compact passbook printer ② Module type ③ Expandability by cluster configuration ④ Human-machine interface improved by real Japanese language processing ⑤ Software productivity improved by general-purpose COBOL	① System expansion simplified by stand-alone/cluster configuration ② OA application packages supplied ③ Banking/Information processings and OA integrated (multiple function/unit)	① Image processing ② Multifunction passbook printer (with OA output, PF read, image read, and page turn functions)
Main element technologies	Processor	8-bit processor			16-bit multiprocessor	32-bit multiprocessor
	Memory capacity	32K	64K	1M	3M	8M
	File	Cassette MT	Floppy disk	60M disk	120M disk	264M disk
	Printer	Printing speed: 40 cps	120 cps	180 cps	180 cps	200 cps
	Network	BASIC protocol (L2A/L2B)	BASIC protocol (L2A/L2B)	BASIC protocol (L2A/L2B)	·High level DINA protocol ·2 line supporting	Corresponding to ISDN

Fig. 10 History of N6390 model changes.

Architecture) protocol, as well as linking with the host system through MML functions are reinforced so that the N6390AG can correspond to information processing systems.

(3) Adopting Real-Image Processing Functions

The passbook printer is incorporated in a contact-type image scanner so that slip images can be read automatically. Data is displayed on CRT screen to simplify input operations. And images are transferred so that transactions can be approved by supervisors immediately when they occur.

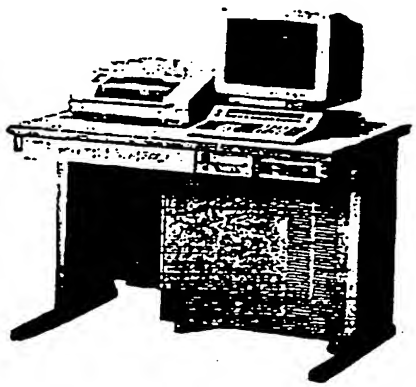


Photo 8 N6390AG.

(4) Adopting CRT Display According to High Counter/Low Counter Jobs

A rear-portion processed compact 12-inch white CRT and a thin-type LCD are adopted for the high counter, while a 14-inch color CRT with touch panel (160° tiltable) is adopted for the low counter, so that the human-machine interface can be greatly improved.

(5) Mounting RAS Functions for Securing High Reliability

In order to have the system recover from line/disk troubles as early as possible, line tracing functions, as well as a removable disk are adopted. Remote maintenance functions for programs in on-line are also mounted.

As the next generation teller terminal, high performance for high-speed processing of transactions, various information supply functions corresponding to sales windows and information outgoing center, as well as high reliability without any down errors are required. In order to meet such needs, NEC is doing its best to research/develop the following technologies.

- AI technology.
- Human-machine interface technology.
- Image-recognition processing technology.
- ISDN networking technology.
- Multimedia processing technology.

(Akira NISHIYAMA)